Predicting the effects of invasive hydrozoa (jellyfish) on pelagic organisms under changing salinity and temperature regimes

#0026

Technical Panel Review

Proposal Name: Predicting the effects of invasive hydrozoa (jellyfish) on pelagic organisms under changing salinity and temperature regimes

Applicant Organization: University of California at Davis

Principal Lead Investigator(s):
May, Bernie
Moyle, Peter

Amount Requested: $430,870

TSP Panel Summary of Findings:

Drs. May and Moyle propose a fascinating study of a serious problem in the San Francisco Bay–Delta – that of the impact of four invasive jellyfish. The proposal is clever, well thought–out, and its focused approach is a strength. There is ample precedent of the impact of invasive jellyfish having devastating impacts on large estuaries (most notably the Chesapeake Bay and the Black Sea), demonstrating a compelling reason to learn more about these organisms in the San Francisco Bay–Delta. With all of the problems confronting the San Francisco Bay–Delta, it is possible that the impact of this group of invaders has been overlooked. To their credit, Drs. May and Moyle propose to bring this issue to light. The project focuses on a topic and geographic area at the very heart of the issues of major concern to CALFED – the factors contributing to the demise of the Delta and more specifically Suisun Bay. In that vein, their proposal is very insightful and hence most worthwhile. The experimental design of the proposal is very thorough with field sampling, genetic analysis and lab experiments. The proposal might be somewhat ambitious because of this broad sweep of studies, yet the two PIs seem to have a good grasp on what needs to be done and how to go about doing the work. The graduate student and technician slated to work on the project look very well qualified and should make good contributions. Despite glowing praise for this proposal, there are some minor concerns. The lead investigators do not bring strong experience in this

subject matter. However, this could also be a strength because they will be approaching the project with a fresh approach. One of the reviewers pointed out that the field sampling might be temporally too coarse to catch the major jellyfish population fluctuations. An additional concern is that the sampling will employ nets in tows. Is it possible that the jellyfish will be shredded by this approach, especially when working in waters with strong tidal currents? Another issue is that the lab experiments as described in the proposal seemed to lack sufficient controls. For example, on page 14 of the narrative, the feeding rate studies rely on the results from a single polyp that is given only an hour to acclimate. The investigators might end up frustrated by inconsistent feeding rates in repetitive experiments. In that case good controls will become necessary to decipher the outcomes. Overall this is a very worthwhile study and one that merits funding. A few issues prevent the proposal from achieving the top rating but the investigators can readily address all of these without changing the overall objectives or greatly enlarging the study.

Relevance to PSP Topic Areas:

High

TSP Technical Rating:
Above Average

TSP Funding Recommendation:
Fund

TSP Amount Recommended: $**430,870**

Conditions:

External Technical Review #1

Proposal Title: Predicting the effects of invasive hydrozoa (jellyfish) on pelagic organisms under changing salinity and temperature regimes

Proposal Number: 0026

Proposal Applicant: University of California at Davis

Purpose

Comments	**This is an extremely well written and clear proposal on an important topic. Non-native jellyfish blooms are becoming a problem in many locations around the world and, not surprisingly, in the great laboratory for non-native interactions, the San Francisco Bay estuary. Enough is known in this system to surmise that these creatures are likely becoming a serious problem and are probably linked to declines of important native and non-native species, but not much is known beyond that. That is, almost anything produced by this study will add to the knowledge base. I was impressed with the long list of testable hypotheses, which should lead to focused conclusions.** **I especially liked the use of genetics to estimate the relative contributions of sexual vs. asexual reproduction among these hydrozoans, a seemingly fundamental question. I'm not sure though whether the title doesn't oversell the project slightly in that it is unlikely that the whole estuary will undergo a major shift in salinity and temperature. That is, changes may occur, but with such large gradients in these variables it is likely that each species will just slide over to areas with its preferred combinations of these variables. My point is that I don't know how predictive this work will be, but that's okay, because we need to know much more about these organisms regardless.**
Rating	

	Above Average

Background

Comments	**There is a conceptual model included which likely helped sharpen the investigator's game plan and which helps orient the reviewer. The team seems to have gathered all the relevant background material they could on the four jellyfish species and on the current ecological state of the estuary.**
Rating	**Sufficient**

Approach

Comments	**Who does what is clear. There is a long list of deliverables that will accomplish the important job of disseminating the results. This includes journal articles, which are what's needed to reach an international community that no doubt will be interested in these findings.**
Rating	**Above Average**

Feasibility

Comments	**There is nothing here that can't be done. The likelihood of success is high because there are so many questions being asked and such a dearth of information to begin with. The invetigators have relevant experience and access to the right facilities. The mix of genetics, field, and ecological lab work is a powerful combination.**
Rating	**Above Average**

Budget

Comments	**I'm not sure how to rate this criterion--too cheap is no good, as is too costly. This multi-faceted work is not inexpensive. However, I thought the individual components were costed at appropriate levels. There is**

	some desirable cost sharing.
Rating	Sufficient

Relevance To CALFED

Comments	There is strong relevance to the CALFED PSP priorities, and especially to both Aquatic Invasive (Exotic) Species, and Trends and Patterns of Populations and System Response to a Changing Environment. These connections are outlined by the investigators. Existing information will of course be incorporated into final products.
Rating	Sufficient

Qualifications

Comments	Moyle, as stated, did write the book on California fishes and he is a well respected fish and aquatic biologist. May is a highly productive leader of a genetics lab that is not afraid to take on large projects and try novel approaches. It's remarkable that he is 100% funded by soft money, given his track record. The remainder of the investigators also appear qualified.
Rating	Superior

Overall Evaluation Summary Rating

Comments	These jellyfish are potentially major monkey wrenches in the ecology of the estaury and are likely here to stay (and maybe even to be augmented with more species). Their appearance corresponds with worrisome dimunitions in important pelagic species or life stages. As such, they deserve scientific attention, and sooner than later. This is an intelligent, well-designed response to the problem and it deserves serious consideration.
Rating	

	Above Average

External Technical Review #2

Proposal Title: Predicting the effects of invasive hydrozoa (jellyfish) on pelagic organisms under changing salinity and temperature regimes

Proposal Number: 0026

Proposal Applicant: University of California at Davis

Purpose

Comments	**This proposal is comprehensive and well organized. The researchers propose an interdisciplinary approach to evaluate the ecology and impacts of invasive hydrozoans in the San Franciso Estuary. The researchers propose to 1) develop and utilize molecular markers to distinguish hydrozoan species (by use of designed snps in flanking regions of microsatellite markers. 2) develop a bank of microsatellites that will allow an evaluation of reproductive mode of the 4 hydrozoan species. 3) conduct extensive sampling to evaluate the abundance of hydrozoans 4) examine the abundance of food base for hydrozoans 5) examine overlap in diet between hydrozoans and selected fish species 6) conduct experiments to evaluate salinty and temperature tolerance 7) conduct experimental work to evaluate food consumption rates for hydrozoans. 8) use these data to develop a model to predict impacts of hydrozoans and to evaluate how water management and/or global warming may influence these impacts.** **The proposal objectives and hypotheses arer very clearly stated and internally consistent. This research area is very timely. Assessing the impacts of exotic species requires considerable information on basic ecology. The proposal aims to fill knowledge gaps of the ecology, distribution and reproductive biology of 4 invasive species of hydrozoans. Because so little information exists, the proposed work will**

	add subtantially to the knowledge base for this problem. The most novel data will include the development of molecular markers for species identification and for the assessment of reproductive biology (evaluation of sexual/asexual/# of clones. This information is important as clonal reproduction can facilitate the rapid spread of invasive species. Further, if multiple clones are detected this could suggest a complex history of invasion.
Rating	**Superior**

Background

Comments	**In general, the proposal is easy to follow and the proposed work is straight forward. The genetic work is well described as is the ecological and laboratory physiological tolerance studies. The background regarding the need for more basic biological information seems pretty straight forward.**
Rating	**Superior**

Approach

Comments	**In general the research is well designed. The molecular work will require considerable effort to develop markers, but this research laboratory has an excellent record for this type of work. The distribution of work among the researchers seems appropriate; Genetics – May/Meek; Ecology – Moyle/Wintzer adn Lab studies – May/Meek.** **This work is likely to result in many peer reviewed publications. Both of the primary PIs have excellent track records in this regard.** **My only criticism is that the construction of a generalized model is not very well documented. It is clear that these data will be useful for building such a model, but it would be useful for the researchers to**

	make this more explicit.
Rating	Superior

Feasibility

Comments	The overall project seems feasible. In general the sampling protocols seem appropriate for adequate testing of the various hypotheses. I have already commented on the molecular work. The field studies to evaluate distribution seem fairly well designed. However, it does appear that the sites for sampling medusae and polyps are not exactly the same. The dietary work seems straight forward, but perhaps more fish should be collected for the comparative work. The laboratory studies are well designed and it is clear that more extensive experiments will be conducted following the first preliminary experiments. I have a few minor comments that the auhors may want to consider. 1) For the comparison of diets: Why not collect more fish? A sample size of 10 seems too low. Further, since only adult fish will be examined the sample size will be even smaller. 2) It is not clear how many plates will be deployed for the polyp sampling. 3) The temperature range described for the experiment does not appear to include treatments that would reflect global warming (1–2 C above the highest current temperature (this is the average, but the extremes may be higher, up to 5 oC?.
Rating	Superior

Budget

Comments	The budget is reasonable for the expected work.
Rating	

	Superior

Relevance To CALFED

Comments	**This work will be very useful for assessing potential impacts of invasive hydrozoans. The work will also allow managers to make some general predictions about future invasiveness of these species. T**
Rating	**Superior**

Qualifications

Comments	**Dr. May has an excellent research record in the area of molecular ecology. Dr. Moyle has extensive experience in the field of aquatic ecology and is exceptionally well qualified to supervise the field studies. I am not aware of Dr. May's experience regarding the lab studies, but these studies appear well designed and fairly straight-forward (in terms of interpretation).**
Rating	**Superior**

Overall Evaluation Summary Rating

Comments	**I was very impressed with this proposal. It was one of the better proposals I have reviewed in the last few years. I think the comprehensive multi-disciplinary approach will provide considerable insights to the invasion ecology for these hydrozoans. The molecular work will be especially useful for species ID and for evaluating the reproductive biology.**
Rating	**Superior**

External Technical Review #3

Proposal Title: Predicting the effects of invasive hydrozoa (jellyfish) on pelagic organisms under changing salinity and temperature regimes

Proposal Number: 0026

Proposal Applicant: University of California at Davis

Purpose

Comments	**The goals, objectives and hypotheses are clearly stated in this proposal. The authors propose to answer the following questions: 1)What are the potential effects of invasive hydrozoa on the SFE ecosystem? 2)What are the key biological and physical factors allowing successful establishment and spread? 3) And how will the imapcts and spread of each species invasion change with future conditions? The authors intend to answer these questions in three main tasks. These include 1)Genetic studies to examine clonal diversity and predominant mode of reproduction, 2) Field studies to estimate densities, patterns of prey preference, and diet overlap with fishes, and 3) Lab studies to quanitify feeding rates, and survival and reproduction under a variety of temperature and salinity regimes.** **These Tasks will contribute to answering the first two questions but does not specifically address the question of the impacts under future conditions of climate change and water management. I expected there to be another Task addressing this question with development of a model.** **This research is timely and important. Pelagic species in the upper SFE underwent a**

	substantial decline between 2002 and 2004, concurrent with large blooms of invasive hydrozoa. Loss of planktonic species, including larval fish, could have severe consequences for the ecosystem. It is unclear, however, why, if these species invaded in the 50's and 70's, they are only now becoming a problem. **The study is certainly justified relative to existing knowledge. Very little is known about these invasive hydrozoa. The authors state that there has been effectively no research beyond specimen descriptions of one species, and apparently even that is questionable.** **The authors have elected to conduct a research project, as opposed to a pilot, demonstration or implementation project. At this point, it is additional knowledge that is required, so a research project is justified.** **As very little is known about the invasive hydrozoa in SFE, the results of this study will add to the base of knowledge. In addition to information specific to SFE and the hydrozoa in question, this study will add to our understanding of invasion biology, in general. It will also contribute to understanding hyrozoan invasions in other estuaries around the world.** **This project will generate novel information. The approaches and methods are not particularly novel. However, Task 2 will develop microsatellite markers for the species involved.**
Rating	**Superior**

Background

Comments	**The authors have developed a clearly stated conceptual model which explains the underlying basis for the proposed work. Sufficient information is included and documented to understand the basis for the proposed work.**
Rating	**Superior**

Approach

Comments	**The authors have designed an approach that is appropriate for meeting most of the objectives of the project. The authors have three main tasks in which they will 1) complete genetic studies for species identification and determination of the relatively contribution of asexual/sexual reproduction by the hydrozoa, 2) complete field studies to examine distribution and abundance, gut contents, and diet overlap with fishes, and 3) complete lab studies to examine feeding rates and temperature/salinity tolerances. Again, the authors do not specifically address the goal to "Predict how the invasions may expand under scenarios of climate change and water regulation and what future effects on the SFE community may be."** **Dr. Bernie May will be the overall supervisor for this project. He has had prior CALFED funding and extensive experience in project management. Dr. May is on soft money and there is money set aside for his salary, as well as for administrative travel.** **Products of this project will include reports, summaries for the public, presentations at CALFED conferences, presentations at regional and national/international conferences, and scientific papers in peer−reviewed journals. In addition, this project will be part of two PhD dissertations.**

	The authors have a dissemination plan, with deliverables for each Task. There is little in the way of public outreach, however. **This project will contribute to an existing long-term sampling database of otter trawl and seine information.**
Rating	**Above Average**

Feasibility

Comments	**The approach is well-documented and apparently technically feasible. The only possible problem mentioned is difficulty in locating and collecting large numbers of medusae of one of the species and polyps of another.** **I would add that another possible problem is the inability to create the genetic markers. Invertebrates are sometimes difficult to work with. No papers concerning genetics of hydrozoa are cited. Nor do the authors report that they have completed preliminary work to see if they can even isolate DNA from the hydrozoans. I would have liked to see this potential problem addressed.** **I would have also liked to have seen a description of the hydromedusae and plankton rearing facilities. It is my understanding that medusae need to be kept moving and in suspension in order to be maintained in captivity.** **Despite these cautions, the likelihood of success appears to be high. The other tasks are not dependent upon completion of the genetics. So even if it fails, the other tasks can continue.** **While the scale of the project is relatively large, it is consistent with the objectives and within the grasp of the authors.**
Rating	

	Above Average

Budget

Comments	**The authors hav developed a budget for each task that clearly defines salaries, equipment, etc. Considering that Dr. May is on soft money and must request salary, the budget is reasonable and adequate for the most part. The request for publication costs may be on the low side.** **It is unclear why the benefits, as % of salary, changes with each task.**
Rating	**Superior**

Relevance To CALFED

Comments	**The proposed research program addresses topics in the Priority Research Topic List. This proposal clearly addresses the topic of Aquatic Invasive Species by examining how hydorzoan invaders are affecting the ecosystem, as well as examining the key factors that have allowed their successful establishment.** **The authors authors also state that the project addresses the topic of Trends and Patterns of Population and System Response to a Changing Environment, as well as the topic of Habitat Availability and Response to Change. While the authors will address the relationship between environmental conditions and hydrozoans, I would argue that they do not specifically address the questions of possible responses of hydrozoans to water regulation or climate change.** **This proposal will integrate and synthesize current and new information on the invasive hydrozoan species, as well as zooplankton and fish communities in SFE. This information will be useful to CALFED resource managers and the Pelagic Organism Decline task force.**

Rating	**Above Average**

Qualifications

Comments	**This project will be headed by two senior researchers, in collaboration with two PhD students. The two senior researchers have an impressive list of qualifications and past performance.** **Dr. May is a geneticist who has studied primarily fish, fungi, birds, mammals and plants. He has studied one invertebrate, the invasive zebra mussel.** **Dr. Moyle is an expert on the ecology of fishes, including invasive species.** **Ms. Wintzer is beginning her program and is studying the feedig biology of fishes.** **Ms. Meek is a third year student and has experience using molecular techniques.** **This looks like a fantastic team. My only concern is that apparently none of the authors have had experience working with hydrozoans. They could remedy this problem by collaborating with an expert, perhaps on a consultation basis.**
Rating	**Above Average**

Overall Evaluation Summary Rating

Comments	**The proposed project is clearly needed and timely to understand the role of invasive hydrozoans in the recent decline of pelagic organisms in SFE.** **I am giving this proposal a rating of "Above Average", rather than "Superior" for the following reasons: 1) The authors do not specifically address their question concerning how the invasion may change in response to future conditions. 2) The authors have not completed**

	any preliminary work on the genetics of the orgainisms. 3) The authors do not have expertise in hydrozoans.
Rating	**Above Average**

External Technical Review #4

Proposal Title: Predicting the effects of invasive hydrozoa (jellyfish) on pelagic organisms under changing salinity and temperature regimes

Proposal Number: 0026

Proposal Applicant: University of California at Davis

Purpose

Comments	**This project proposes to study the genetics and ecology on several invasive species of hydrozoa on pelagic organisms (mainly fish larvae and zooplankton) in the upper, more oligohaline reaches of the San Francisco Estuary. The goals of this project are clearly stated. The quantitative importance of these invasive planktivorous jellyfish is not well documented; one short paragraph sites an unpublished data report stating that densities can reach "more than 500 individuals per m3" and another stating that "tens of thousands" of individuals have been collected in the Napa River. It is very difficult for a remote reviewer to judge how important these hydrozoan jellyfish species are based on this sort of largely anecdotal information. Based on this uncertainty, I would judge that a pilot or demonstration study would be easier to justify than this full blown project, studying everything from ecology to genetics. I would think it more prudent to first get good quantitative information on the extent of the problem. I think this would provide some important information, but the study would not be especially novel in its methodology or approaches**
Rating	**Sufficient**

Background

Comments	**I think the ecological portion of this study is based on a clear conceptual model. I found the genetic work to be less clearly justified. The authors propose to develop microsatellite markers to identify the hydrozoan species. I don't see why this is an advance over traditional systematic approaches. These species have clear moprphological characteristics, and can be identified by examining them with a dissecting microscope. I don't see the advantage of developing molecular markers. I also don't see the need for determining the clonal diversity, when we don't even know if these introduced species represent an important ecological threat.**
Rating	**Sufficient**

Approach

Comments	**I think there are some weaknesses in the proposed approach, at least in the ecologic field and laboratory studies. Field sampling is proposed once per month from July to October (4 times per year). I do not think this is adequate for sampling hydromedusae, which can be quite ephemeral in their distribution both spatially and temporally. I would recommend sampling at 2 week intervals, since the season is only four months long. Some of their sampling sounds a little challenging – for example sampling with a mid−water trawl in sloughs that are at best 2−3 meters deep? I found it frustrating that the size of these jellyfish was never mentioned, so it was difficult to get a sense of the appropriateness of the sampling or laboratory study methods. Also, I found the design of their feeding studies rather simplistic. Looking at feeding selectivity based on gut contents is complicated by the differential digestion times of different types of prey. Soft bodied prey tend to digest faster (fish larvae) than prey with exoskeletons (planktonic crustacean). This leads to**

	problems with the feeding selectivity studies they propose. No mention is made of experiments to correct this problem. The laboratory feeding experiments are also pretty simplistic. Nobody cares about feeding rates of these jellyfish on Artemia nauplii; only studies with natural zooplankton species from the study site are relevant. Also, just sticking the jellyfish in a bid jar is not appropriate. The standard approach for feeding studies of gelatinous zooplankton is to use plankton kreisels. The authors should visit the jellyfish display at the Monterey Bay aquarium or speak to Bill Hamner.
Rating	Inadequate

Feasibility

Comments	I think the methods need to be improved to obtain the desired results (see above). I have greater confidence that the proposed genetic studies are indeed feasible, but I don't think they are particularly well justified at the present state of knowledge of the ecological importance of these invasive species.
Rating	Sufficient

Budget

Comments	I think the budget seemed clear and reasonable, although I didn't spend much time scrutinizing it due to the other weaknesses I found in the overall proposal.
Rating	Above Average

Relevance To CALFED

Comments	I think this study fits well into the priorities stated in the PSP. I think only a pilot or demonstration project is justified at this point, so it can be determined if this is an important ecological issue, and if the proposed methods are capable of providing the

	type of field information needed.
Rating	Above Average

Qualifications

Comments	Both PI's have excellent publication and research records. My issue would be that they don't have any obvious experience in studies of jellyfish or zooplankton, and this is evident in the methods they propose for field and lab studies. The lead PI is a geneticist, and the co-PI is a freshwater fish expert. They need to collaborate with someone who has experience with studies of zooplankton and especially jellyfish. For example, Wim Kimmerer at Tiburon, or Bill Hamner at UCLA (I know he is retired, but he would probably be willing to consult or help).
Rating	Above Average

Overall Evaluation Summary Rating

Comments	I can not recommend this full project as high priority for funding. I think a pilot field study could be justified to get a better handle on the extent of the problem associated with this invasive species. I think the PI's should consult with a zooplankton ecologist to improve their methods and help train the graduate students who will be doing the majority of the work.
Rating	Sufficient